

THE NCC PROJECT : A QUALITY MANAGEMENT PERSPECTIVE

Raymond H. Lee
Computer Sciences Corporation
10110 Aerospace Road
Seabrook, Maryland 20706

(301) 794-1600
(301) 552-3272 (FAX)

Summary

The Network Control Center (NCC) Project introduced the concept of total quality management (TQM) in mid-1990. The CSC project team established a program which focused on continuous process improvement in software development methodology and consistent deliveries of high quality software products for the NCC. The vision of the TQM program was to produce error free software. Specific goals were established to allow continuing assessment of the progress toward meeting the overall quality objectives. The total quality environment, now a part of the NCC Project culture, has become the foundation for continuous process improvement and has resulted in the consistent delivery of quality software products over the last three years.

Background

The Network Control Center (NCC) Project has had a long history of developing and maintaining software to assure that the system stays abreast of the changing needs of the Space Network. The NCC must schedule, control, and monitor the real time activities associated with providing communications support to spacecraft requiring the capabilities of the Tracking and Data Relay Satellite System (TDRSS).

In 1989, a major initiative was underway to modernize the White Sands Complex by establishing a Second TDRS Ground Terminal and upgrading the existing terminal to handle the projected workload for the late 1990s. These changes in the Space Network necessitated major changes in the NCC to assure that control center software would be compatible with the ground terminal environment. This development activity was designated as NCC Block 3 and the project was tasked to develop software that would be delivered in three releases. The first release would accommodate the changes necessitated by the Second TDRS Ground Terminal (STGT). The software product would have to operate with formats and functionality that could support the current ground terminal environment and the STGT. The second release was to be designed to handle the STGT and the White Sands Ground Terminal Upgrade (WSGTU). The final release

had the objective of providing the capability to schedule, control, and monitor a four or more TDRS constellation. The planned completion of the NCC Block 3 software upgrades was scheduled for 1995.

In parallel with the challenge to develop the Block 3 software, the NCC Project had to provide software enhancements to the operational baseline to address known system deficiencies and planned hardware upgrades. These activities were to be accomplished under the NCC Block 1 or maintenance effort. Maintenance deliveries were planned for each fiscal year and all operational baseline changes were integrated into the development baselines.

All development planning actions had to take into consideration the impact of the ongoing maintenance tasks.

Management Realignment

Within the context of this phased software development effort, the concept of total quality management was introduced in mid-1990. During the same time frame Goddard Space Flight Center (GSFC) management aligned the NCC Project software development efforts within the Flight Dynamics Division (FDD) from the traditional Networks Division (ND) in the Mission Operations & Data Systems Directorate. This action was taken because it was determined that the appropriate project management structure had to be in place for the NCC Block 3 software development objectives to be successfully met. This structure was not in place in the Networks Division nor was there sufficient expertise to establish the required organization. Thus, a project organization was established within the FDD to manage the CSC SEAS NCC Project Block 3 software development effort.

In concert with the management changes made on the GSFC staff, CSC assigned a new project manager and deputy project manager to lead the NCC Project. This new team established, within the NCC Project, a total quality program which focused on continuous process improvements in the software development methodology and consistent deliveries of high quality software products for the NCC. The vision of the total quality program was to establish and maintain an environment in which software products could be developed and delivered error free. To accomplish this goal, the project had to emphasize its

understanding of customer needs, appreciate the value of continuous process improvement, and recognize the importance of team building and effective communications.

Several measures of merit were established to allow for continuous assessment of the progress toward meeting the overall quality objective. These measures were categorized as the "FOUR P's": Product; Process; Performance; and Participation. The "Product" criteria was measured in terms of the quality of delivered software and the project's ability to deliver on schedule and within budget. The critical quality measures were related to the error rates during system and acceptance testing. The "Process" criteria was measured in terms of process improvements implemented which contributed to product quality and/or cost avoidance. These accomplishments are documented in success stories and task improvement initiatives. The "Performance" criteria was measured by the monthly award fee evaluations. The performance target was to achieve at least 50% plus evaluations during a given fiscal year. The "Participation" measure was the percentage of project personnel who participated in TQM activities. The target was to achieve and sustain a 75% participation rate. Measurements against these goals are accomplished on a monthly basis and feedback is provided to project personnel through newsletters and all-hands meetings.

The NCC Project TQM environment provided the framework for continuously improving the quality of all NCC products and services to meet established goals and objectives. The TQM environment established a highly participative management methodology that complemented the NCC organizational structure. The focus of the methodology was a long-term commitment to improving the quality of products and services. This methodology used a hierarchy of NCC management-chartered committees to improve the quality of NCC processes and products. These committees accomplished this by identifying, assessing, measuring, analyzing, and documenting processes, issues, and products and recommending improvement action plans to management.

The TQM program was implemented through the NCC Quality Management Board (QMB), designated permanent committees and selected ad hoc committees. The five permanent committees include the Suggestion Analysis and Resolution Group (SARG), the Customer Satisfaction Committee (CSAT), the Worklife and

Communications Committee (WLCC), the Process Improvement Committee (PIC), and the Awards and Recognition Committee (ARC). The SARG was chartered to analyze suggestions for improving products and processes. Following the analysis, a recommendation for implementation would be provided. The CSAT was chartered to establish consistent and meaningful mechanisms for obtaining client feedback and measuring customer satisfaction. The WLCC was chartered to develop, implement, and facilitate an effective NCC communications program. The PIC was chartered to focus on methods to improve technical processes. Many of the ad hoc Process Action Teams (PATs) evolved from PIC initiatives to update or modify existing procedures. The ARC was chartered to develop, implement, and facilitate the NCC recognition program. Their work was the basis for the monthly recognition program at all-hands meetings and the annual NCC DATUM award to the project employee of the year.

The Total Quality Impact

Given the scope of the tasks that the project had to accomplish, the organizational environment (i.e. the FDD GSFC management team), and the newly established TQM environment for the SEAS NCC project team, a look at the results and on-going activity provides an interesting perspective on how a large software development project can succeed.

One of the most important contributors to success was responsiveness. This was demonstrated in the initial transition of the project to the FDD. Close coordination and communication among all parties, intense effort, and a strong desire to succeed paved the way to assure a smooth transition took place. Responding to five new task assignments which mapped to the development, maintenance, system engineering, system testing, and security requirements, the NCC project team replanned all the work in less than one month. To expedite task planning, CSC management and technical personnel worked closely with GSFC managers to familiarize them with the NCC system architecture, software environment, and system functionality. Frequent meetings between the project task managers and their GSFC counterparts ensured that the technical effort mapped correctly to the new task structure.

During the transition, project personnel were preparing to meet two critical milestones. On August 7, 1990, the CDR for Block 3, Release 1 was held

successfully. Related deliveries included the detailed design document, operations concept document, quality assurance plan, system test plan, and configuration management plan - collectively, more than 4000 pages. This event concluded the detailed design phase and clearly demonstrated the readiness for software implementation. The relatively small number of Review Item Disposition (RIDs) (31), none of which affected the overall design direction, testifies to the high quality of the design. The second event was the delivery on September 17 of the FY90 maintenance release to acceptance testing 2 weeks early. The quality of the software was evident from the low number of problem reports (11) identified and corrected during system testing. This release, designated 90.1, completed acceptance test one month earlier than scheduled. Release 90.1 was the first delivery to operations in which the label "error-free" could be applied since there were no errors associated with new or modified functions.

As the project stabilized in the FDD environment, significant milestones continued to be met. The FY91 maintenance release, 91.1, completed system testing as scheduled. The upgrade of the Communications and Control Segment (CCS) VAX to an 8550 processor configuration was system tested and integrated into the operational configuration. The Block 3, Release 1, Build 1 activity completed integration testing on schedule and made significant progress in implementing Build 2 during the spring of 1991. Release 91.1 was delivered to operations during the summer of 1991. This release consisted of operating system upgrades to both the UNISYS and DEC processors. These upgrades were implemented as a risk mitigation action for Release 1 to minimize the amount of change occurring with a planned development release. The lesson learned was that operating system changes in a real time system environment can have unexpected results as was evident during transition to operations. Both timing and performance deficiencies were uncovered which required quick fix actions to maintain system stability. The final delivery for release 91.1 was accomplished in November 1991.

In parallel with the maintenance activity, the Block 3, Release 2 CDR was successfully held in October 1991, while system testing of the Release 1 final build was progressing as planned. As another risk mitigation activity, the system test team performed limited interface testing with STGT while it was at the vendor's site. These tests proved invaluable in uncovering problems early

and assigning responsibility for resolution. This activity contributed to the establishment of the interface incident reporting (IIR) process which is now in place to document and resolve interface incompatibilities within the Space Network. Block 3, Release 1, was delivered to acceptance test in March 1992 on schedule and within budget. The release was over 100,000 Delivered Source Instruction (DSI) and a relatively small number of problem reports were identified during acceptance testing. After a successful ORR on August 27, 1992, the Block 3, Release 1 (Release 92.1) was successfully transitioned to operations on September 25, 1992.

To achieve this successful delivery over a two year period, several significant process improvements were put in place, resulting in a more disciplined software development environment and a significantly higher quality product. During implementation, all changes were subjected to a rigorous design, code, and unit test inspection and certification process. The configuration management team implemented procedures that reduced baseline build errors by over 50 percent. The system test team developed more detailed functional and regression test procedures that reduced the number of errors found by the acceptance test team by over 25 percent of that projected for a release of this size. Overall, the software engineering process improvements implemented during the Release 1 development cycle have resulted in a capability for the NCC to be compatible with all Space Network elements and to operate more reliably in the STGT era.

Block 3, Releases 2 and 3 are still under development and progressing as planned. Release 93.1, the FY93 maintenance release, was successfully delivered to operations on August 25, 1993 with the highest quality measure for any NCC delivered product.

The Transition Back To Networks Division

After two and a half years, the software development effort was transitioned back to the Networks Division. The lessons learned from the Flight Dynamics software management experience were an integral part of the successful transition back to the Networks Division. A comparable GSFC management team was established to work with the Computer Sciences Corporation (CSC) NCC Project management team.

In order to accomplish a successful transition, a plan was developed in which a period of 9 months was allocated for transition activities. The first step was to establish a comparable GSFC technical management team in the Networks Division. This team was carefully selected and in April 1992 they began attending the weekly task meetings. This provided a mechanism for the new team to become familiar with the technical issues, the development methodology, and the technical management roles and responsibilities. During the first 6 months of the transition period, the FDD team was in the decision making role for the project. During the last 3 months, the ND team took the lead while the FDD team assumed the role of adviser and observer. At the beginning of 1993, the transition was completed without impact on any critical NCC milestones.

Key Lessons Learned

The key lessons learned were in four areas: (1) commitment at all levels in the project - both CSC and GSFC; (2) requirements control and effective change management vital; (3) product focus as well as process focus is key to success; and (4) consistent measurement of critical success factors.

The management commitment to the NCC Project was visible and sincere on the part of GSFC and CSC. In the spring of 1990, CSC not only selected a new management team for the project but also established periodic meetings between senior MO&DSD personnel and CSC corporate personnel. These meetings were held quarterly and provided the forum for discussion of issues which might impact the project's objectives. The participants at these meetings included the Director and/or Deputy Director of MO&DSD, the CSC Systems Group President, the Systems Sciences Division President, the SEAS Program Manager, and the SEAS Deputy Program manager. This level of commitment assured that the appropriate level of attention and resources would be applied should an issue arise which could potentially impact the project. The periodic meetings continued through the transition of the project back to the Networks Division and will be convened in the future as required.

Requirements control and change management were vital to the success of the project. The management decision to separate the software development activities from the requirements definition functions was critical to requirements control. The GSFC FDD management team had the responsibility to focus on the software development progress and control the growth of the system. As new or changed requirements were identified by the ND NCC Project Office, an impact assessment was performed and a conscious decision was made to consider adjusting established milestones and resources to accommodate new requirements. In addition to the external pressures to change requirements, there were internal proposed changes that were identified during the design and development phases of the implementation. To control these changes, processes were put in place for both technical and management reviews of all proposed changes through the Technical Review Board (TRB) and Configuration Review Board (CRB). These internal project reviews are an integral part of the change management process and provided a more rigorous approach to managing the scope and size of the software effort.

With the establishment of the Total Quality Management Program, there was significant emphasis on continuous process improvement. However, in parallel with that emphasis, there was need to keep the focus on product improvement as well. This was accomplished by establishing a clear cut vision which focused on the product and challenged project personnel to develop and deliver error-free software. By having this focus, all impacts of process improvement activities could be measured either directly or indirectly with the quality of the delivered release. The result of the product focus can be seen in Figure 1 which shows the error rate of the major releases over the last four years. The results of the process improvements are readily seen in the trends showing a steady decrease in the error rate during system and acceptance testing.

The final area where lessons were learned was in the establishment of a measurement program and sustaining it to provide visibility into the project's progress toward meeting targeted objectives. The "Product" measure as stated above was the error rates experienced during the test phases. This is illustrated in Figure 1. The impact of the quality initiatives is clearly seen in the error rate in releases 92.1 and 93.1 which were .24 and .19 errors/KDSI respectively. The "Performance" measure is shown in Figure 2 where the goal

of 50% plus evaluations is on target through fiscal year 1993. The "Process" measure of success stories is demonstrated by the fact that during FY1993, there have been 18 success stories written by project members with a total cost avoidance value of \$ 387,000 . The final measure was "Participation". During the current fiscal year, participation has exceeded 85% of project personnel. These measures have been used for management assessment of the TQM program, but these initiatives have had a much deeper impact on the project. The total quality environment is now a part of the NCC Project culture. It remains the foundation for continuous process improvement on the project and is the basis for the consistent quality of all NCC software products.

FIGURE 1
NCC RELEASE ERROR RATES

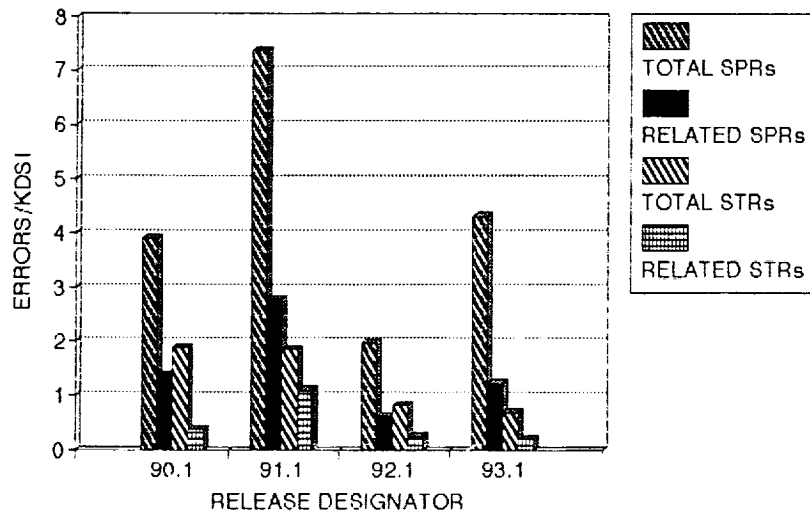


FIGURE 2
NCC PROJECT PERFORMANCE

